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Research Article

Gifted students' skill in solving mathematics problems: A study used gender and ethnicity as differentiating factors in senior high school

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ABSTRACT

This study investigated the skills of math gifted students in high school to solve math problems. Specifically, the researcher took two factors: gender and ethnicity, as differentiators. This study involved 36 mathematically gifted students from three different schools who were randomly se-lected from 48 gifted students who were identified. The two data collection instruments used were mathematical problems (Number Theory, Algebra, and Geometry) and questionnaires, which were organized by referring to Lester's problem-solving stages. The results of the two-way ANO-VA test revealed that the average math problem skill score was 50% of the maximum score (rela-tively low). Another important finding, statistically, there is no difference in math problem skill scores based on either ethnicity or gender. This study implicitly shows that mathematically gifted students in problem-solving processes were not correlated with ethnicity or gender.

Keywords: Gifted Students; Solving Mathematics Problem; Senior High School; Gender; Ethnicity

1. INTRODUCTION

Problem-solving in mathematics teaching is an area of re-search that focuses on analyzing how problem-solving activi-ties play a position. The position in question is related to con-tinuously understanding and using students' mathematical knowledge to develop and perfect mathematical prob-lem-solving competencies. The role of students as a part of the learning community is to promote modeling activities in con-structing, utilizing and associating mathematical concepts to solve various problems (Liljedahl, 2016). The call for problem-solving-based learning is carried out at all levels of education, including at the high school level, es-pecially for mathematics and science subjects. It is contained in many educational documents such as the Indonesian national curriculum, the NCTM Principles and Standards in Ameri-ca (National Council of Teachers of Mathematics, 2000), the National Curriculum for England(Department for Education, 2013), the Australian Curriculum (Australian Curriculum Assessment and Reporting, 2017), Etc. These documents also describe where problem-solving is positioned in each lesson, including indicators of its implementation. Excluding being a part of five strands of mathematical fluency, problem-solving also has significant roles: it evokes thinking and reason and initiates a good understanding if used to introduce new con-cepts and skills (Charless, 2009).

The focus in the problem-solving process is not only looking for a solution to the problem, but several steps must be taken, including problem identification, problem clarification, data collection, data selection and organization, determination of possible solutions, and solution evaluation (Billstein, 1982). In comparison, Polya developed the problem-solving process into several steps: understanding the problem, constructing plans, implementing plans, and looking back (Polya, 1949). In general, students with good mathematical prob-lem-solving skills are gifted students. Regardless, the definition of gifted students is still being debated (Sheffield, 2017). Kru-tetski defines mathematically gifted as a unique set of math-ematical abilities that open the possibility of successful per-formance in mathematical activities (Krutetski, 1976). In con-trast, the NCTM defines it as a function of maximizing varia-bles such as ability, motivation, belief, and experience or op-portunity (NCTM, 2000).

In more detail, gifted students have characteristics as in-dependent learners who have high motivation, diligently use the time when doing assignments, have a high curiosity and are inclined to take risks (Argun, 2017). In addition, they tend to compete to be the best among themself and get different characteristics. Their mathematical abilities are not only po-tential and actual abilities but some general abilities: intellec-tual, special academic, productive and creative thinking, and psychomotor (Worrell et al., 2019). Many previous studies have demonstrated the superiority of those who are mathematically gifted compared to non-gifted students-support problem-solving skills. (Heinze, 2005) showed that gifted students worked systematically and, quickly understanding the structure of mathematical problems, expressed and explained their solutions more effectively. In addition, (Keleş, 2021) found that gifted students' inter-task flexibility was higher than intra-task. Similarly, (Krutetski, 1976) added that the reversibility of mental processes also appears when gifted students perform mathematical reasoning.

Many studies have tried to correlate mathematics perfor-mance with variables such as gender, grade level, background, and learning strategies (Cleary & Chen, 2009; Kashefi et al., 2018; Oginni, 2018; Peteros et al., 2019; Wang, 2017). In contrast to the study of mathematical performance, more specif-ically, mathematical giftedness crystallizes more on gifted students' unique thinking and performance characteristics, such as creativity, flexibility, formalization, and memory capability (R Leikin, 2017; Tjoe, 2015). Therefore, widening the study of mathematical giftedness and its relation to gender, background, and many other factors will deepen under-standing of it. Another element that plays a significant role in mathemat-ical giftedness is the learning environment. (Haataja et al., 2020)presented that a good learning environment for gifted students fosters shared motivation, healthy perfectionism, and practice social skills. In addition (Rotigel & Fello, 2004) noted more specifically that gifted students need a learning envi-ronment that can accommodate learning strategies and unu-sual thinking natures. On the other hand, math gifted students are often in a standard learning environment and get learning like other non-gifted students. Another critical challenge is the learning environment that involves a rich and complex diversity ranging from social backgrounds to academic abilities (Cross, 2021; Reed, 2004; Valero et al., 2015). In many investigations, the social background of students is also frequently associated with academic achievement in specific subjects, including mathematics (Aldous, 2006; Blömeke et al., 2012; Valero et al., 2015; Yan & Lin, 2005). The question that arises is whether the same consequences apply to gifted students.

One of the topics about the social background that has been infrequently examined in mathematics education research is ethnicity. It is caused by several factors, such as the dominance of certain ethnic groups over others (Gillborn, 2015)and the unfair distribution of education (Joseph & Matthews, 2014). In certain regions or countries, ethnicity and even race are often essential factors affecting social life, including specific areas such as mathematics education (Else-Quest et al., 2013; Peterson et al., 2016). Therefore, it is suspected that these factors have an impact that is not simple in the context of education, including giftedness in mathematics. Established on the complex description described, the re-searcher considers it urgent to identify the gifted student's problem-solving skills of high school mathematics by using gender and ethnicity as factors.

Hypothesis:

H_0 : There is no difference in mathematics problem-solving skills among student's groups based on gender ($\mu1=\mu2$)

H_1 : There is a difference in mathematics problem-solving skills among student's groups based on gender($\mu1\neq\mu2$)

H_0 : There is no difference in mathematics problem-solving skills among student's groups based on ethnicity ($\mu1= \mu2=\ldots=\mu3$)

H_1 : There is a difference in mathematics problem-solving skills among student's groups based on ethnicity (other than H0)

2. RESEARCH METHOD

This comparative study involved mathematically gifted students in three senior high schools in three different cities in North Maluku, Indonesia. The sample consisted of 36 gifted students consisting of 18 boys and 18 girls. Due to the restricted number of mathematically gifted students, the sample selection was conducted by purposive sampling with the approval of the math olympiad coaches in each school and was found 48 gifted students. The following step was random sampling, then successfully gained 36 students. All research subjects are par-ticipants in the mathematics olympiad at the regional level. Furthermore, the identification of gender and ethnic back-ground of each research subject through filling out the form so that a sample is obtained that represents all factors: gender and ethnicity. The selected ethnicity is the native ethnic group in North Maluku: Makian, Tobelo/ Galela, Ternate, and Tidore.

The data collection of mathematical problem-solving skills is carried out utilizing two instruments, namely the equivalent of a math olympiad level consist of three fields: number theory (Figure 1), algebra(Figure 2), and geometry(Figure 3), that has been tested for validity and reliability and a questionnaire that refers to the stages of Lester's problem-solving(Haavold & Sriraman, 2021) : Orientation (5 questions), Organization (3 questions), Execution (5 questions) and Verification (4 ques-tions) (Table 1). The score of every response to every question uses a scale of 0-1. The process commences when the research subject solves the three math problems on the worksheet. Process followed by students answering the questionnaire in writing on the filling sheet for each question area. In the last stage, the researcher conducted a short interview to confirm the responses to the questionnaire and give a score.

A. Bidang Teori Bilangan

Banyaknya bilangan asli $n \leq 2015$ yang dapat dinyatakan dalam bentuk $n = a + b$ dengan a, b adalah bilangan asli yang memenuhi $a - b \in Bilangan\ Prima$ dan ab adalah bilangan kuadrat sempurna adalah...

Figure 1. Number Theory Problems

B. Bidang Aljabar

Misalnya $P(x)$ adalah suatu polinom berderajat empat yang memiliki nilai maksimum 2018 di $x = 0$ dan $x = 2$. Jika $P(1) = 2017$, maka nilai $P(3)$ adalah ...

Figure 2. Algebra Problems

C. Bidang Geometri

Diketahui persegi $ABCD$ dengan panjang sisi 1. Titik K dan L berturut-turut terletak pada segmen garis BC dan DC sehingga keliling $\Delta KCL = 2$. Luas minimum ΔAKL adalah...

Figure 3. Geometry Problems

The data analysis process starts with grouping the average question response scores on the questionnaire for all fields (Number Theory, Algebra, and Geometry) established on gender and ethnicity. The second step is to test the normality of the data on the average score of math problem-solving skills and continue to test the homogeneity of the data based on two factors. After confirming that the data has met the requirements of the hypothesis test, the process is continued by conducting a two-way ANOVA test to answer the research hypothesis. The interpretation of the analysis results is the last stage in this study which will present the results of descriptive statistics, the average score of problem-solving skills, and standard deviation. The results of the two-way ANOVA test comprise the Test Between Subject Effect (Corrected model, Intercept and R Squared) and Post Hoc output which contains the difference in average scores based on gender and ethnicity.

Table 1. Questionaire of Problem-Sloving Stages

No.	Questions	Score (0-1)
	Orientation	
1	Explain what the problem is.	
2	What information is available in the questions? Explain	
3	Are the available information sufficient? Explain	
4	Is there any confidential information in the questions? If yes, please mention.	
5	Are there assumptions and estimates that can be made to simplify the problem? Explain	
	Organization	
1	Explain how the solution flow plan will follow?	
2	What patterns or structures will use to find a solution?	
3	Before finding a solution, what information should find first?	
	Execution	
1	Describe in writing the strategies and manipulations used to find the solution.	
2	Explain the meaning of each symbol and equation that use.	
3	How to check the suitability of the problem-solving steps with the plan that was made earlier?	
4	How to detect possible errors throughout the problem-solving process?	
5	Is there a shortcut or a fast way used to find a solution? If Yes, please explain.	
	Clarification	
1	Do you re-examine every step of the work that has been done? If so, please explain how to check it.	
2	During finding the solution, do you find the error and make corrections? If yes, please state what improvements you made.	
3	Is there any alternative way that can be used to find a solution? Do the answers you have found make sense? Why?	
4	Do you re-examine every step of the work that has been done? If yes, please explain how to check it.	

3. RESULTS AND DISCUSSION

3.1 Test of Normality

Based on the SPSS output in Table 2, it is known that the statistical value for Kolmogorov-Smirnov is 0.142 and Sig or p-value 0.065 > 0.05, telling that the average score data for mathematical problem-solving skills come from a normally distributed population. Moreover, the distribution of data in the form of dots on the Normal Q-Q Plot image in Figure 4 does not form a pattern and tends to be close to the line indicating the same conclusion.

Table 2. Test of Normality Results

Tests of Normality

	Kolmogorov-Smirnov^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Problem Solving	,142	36	,065	,903	36	,004

a. Lilliefors Significance Correction

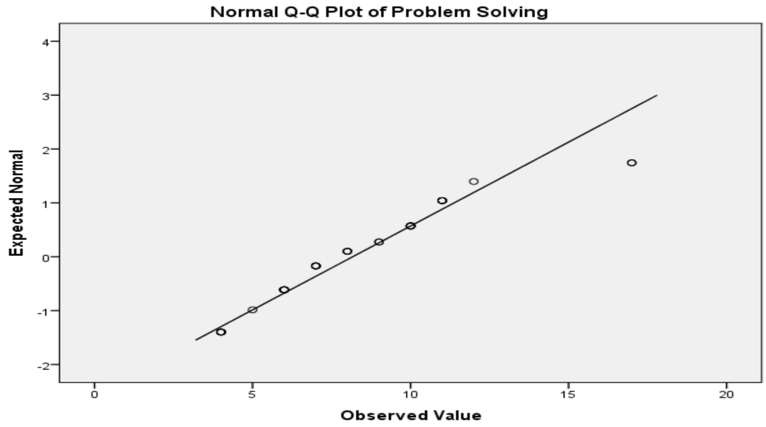

Figure 4. Q-Q Plot Curve

3.2 Test of Homogeneity

3.2.1 Homogeneity Test Results Based on Gender

The results of the analysis in Table 3 Test of Homogeneity of Variances obtained F = 1.327 df 1 = 1, df 2 = 34 and p-value = 0.257 > 0.05. Thus, the data on mathematical problem-solving skills of the two gender groups is homogeneous.

Table 3. Test of Homogeneity Result Based on Gender

Test of Homogeneity of Variances

Problem Solving

Levene Statistic	df1	df2	Sig.
1,327	1	34	,257

3.2.2 Homogeneity Test Results Based on Ethnicity

The outcomes of the analysis in Table 4 Levene's Test of Equality of Error Variances gained F = 0.573 df 1 = 3, df 2 = 32 and p-value = 0.637 > 0.05, indicating data on mathematical problem-solving skills of students from the four ethnic groups (Makian, Tobelo /Galela, Ternate, Tidore) homogeneous.

Table 4. Test of Homogeneity Result Based on Ethnicity

Levene's Test of Equality of Error Variances^a

Dependent Variable: Problem Solving

F	df1	df2	Sig.
,573	3	32	,637

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Suku

3.3 Descriptive Statistics

The outcomes of the descriptive analysis in Table 5 demonstrate that the average total score of the mathematical problem-solving skills of 36 gifted students is 8.17, and the standard deviation is 3.212. This achievement is almost half of the maximum score obtained by the research subjects, which is 17.

Table 5. Descriptive Statistics Result of Whole Score of Problem-Solving Skill

Descriptives

			Statistic	Std. Error
Problem Solving	Mean		8,17	,535
	95% Confidence Interval for Mean	Lower Bound	7,08	
		Upper Bound	9,25	
	5% Trimmed Mean		7,91	
	Median		7,50	
	Variance		10,314	
	Std. Deviation		3,212	
	Minimum		4	
	Maximum		17	
	Range		13	
	Interquartile Range		4	
	Skewness		,997	,393
	Kurtosis		1,345	,768

3.4. Results of Hypothesis Test

Table 6 shows the variance of the average value of problem-solving skills by gender and ethnicity. Based on Table 5, information is obtained that the highest average was achieved based on ethnicity by gifted students from the Makian ethnic (8.67) and the lowest from gifted students from the Tobelo Galela ethnicity (7.67). Furthermore, based on gender, the highest average score was gained by the group of gifted female students from the Makian group (9.60), and the lowest was the male gifted student group from the Ternate and Makian groups respectively (7.50). However, overall, the difference in the average achievement of these scores is not significantly different. Moreover, there is a significant difference between the maximum and average scores for each group, based on ethnicity and gender.

Table 6. Descriptive Statistics Result Based on Ethnicity and Gender

Descriptive Statistics

Dependent Variable: Problem Solving

Suku	Gender	Mean	Std. Deviation	N
Makian	Laki-laki	7,50	3,317	4
	Perempuan	9,60	4,506	5
	Total	8,67	3,937	9
Tobelo/Galela	Laki-laki	7,75	2,872	4
	Perempuan	7,60	3,286	5
	Total	7,67	2,915	9
Ternate	Laki-laki	6,50	2,082	4
	Perempuan	9,00	4,796	5
	Total	7,89	3,855	9
Tidore	Laki-laki	8,00	2,757	6
	Perempuan	9,33	1,155	3
	Total	8,44	2,351	9
Total	Laki-laki	7,50	2,595	18
	Perempuan	8,83	3,682	18
	Total	8,17	3,212	36

The output of Leven's Test of Equality of Error variances is the result of a test to determine the homogeneity of variance of gifted students' math problem-solving skill scores. Table 6 shows the significant value of Sig. 0.558 > 0.05 means that the variance of the mathematical problem-solving skill score variable is homogeneous.

Table 7. Output of Leven's Test of Equality of Error variances

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Problem Solving

F	df1	df2	Sig.
,848	7	28	,558

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Suku + Gender + Suku * Gender

Output Test of Between-Subject Effects in Table 8 is the output of hypothesis testing in this study where the decision to reject and accept the research hypothesis was taken out. On the ethnic factor, it is known that the significance value is Sig. 0.896 > 0.05, so the hypothesis about the differences in the mathematical problem-solving skills of gifted students based on ethnicity must be rejected. In the same way, the significance value for the gender factor is Sig. 0.224 > 0.05. It means that there is no difference in the mathematical problem-solving skills of gifted students based on gender. The other important point is that the analysis results show that ethnicity and gender factors simultaneously do not drive differences in math problem-solving skills. A significance value of Sig indicates this, which is 0.854 > 0.05. Furthermore, the value of the R-squared of ethnicity and gender factors and mathematical problem-solving skills is 0.092, which reveal a very weak correlation. More specifically, the distinction in the average score of mathematical problem-solving skills of gifted students from all ethnic groups is presented in Table 9.

Table 8. Output of Test of Between-Subject Effects

Tests of Between-Subjects Effects

Dependent Variable: Problem Solving

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	33,183[a]	7	4,740	,405	,891
Intercept	2303,737	1	2303,737	196,770	,000
Suku	6,985	3	2,328	,199	,896
Gender	18,079	1	18,079	1,544	,224
Suku * Gender	9,105	3	3,035	,259	,854
Error	327,817	28	11,708		
Total	2762,000	36			
Corrected Total	361,000	35			

a. R Squared = ,092 (Adjusted R Squared = -,135)

Table 9. Output Pos Hoc

Multiple Comparisons

Dependent Variable: Problem Solving
Tukey HSD

(I) Suku	(J) Suku	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Makian	Tobelo/Galela	1,00	1,613	,925	-3,40	5,40
	Ternate	,78	1,613	,962	-3,63	5,18
	Tidore	,22	1,613	,999	-4,18	4,63
Tobelo/Galela	Makian	-1,00	1,613	,925	-5,40	3,40
	Ternate	-,22	1,613	,999	-4,63	4,18
	Tidore	-,78	1,613	,962	-5,18	3,63
Ternate	Makian	-,78	1,613	,962	-5,18	3,63
	Tobelo/Galela	,22	1,613	,999	-4,18	4,63
	Tidore	-,56	1,613	,986	-4,96	3,85
Tidore	Makian	-,22	1,613	,999	-4,63	4,18
	Tobelo/Galela	,78	1,613	,962	-3,63	5,18
	Ternate	,56	1,613	,986	-3,85	4,96

Based on observed means.
The error term is Mean Square(Error) = 11,708.

The findings in this study confirm that gender and ethnicity are not significant factors in the mathematical performance of gifted students. However, giftedness itself is a factor that supports problem-solving skills. (Sriraman, 2003) explains a relationship between mathematical talent, problem-solving ability, and the ability to generalize and abstract equity and form good conceptual relationships. It will further support problem-solving skills by solving them in various ways(Roza Leikin et al., 2009). However, occasionally this gift is not always indicated by achievement in mathematics at school(Parish, 2019).

Many researchers have diverse views regarding gender and its role in mathematical problem-solving abilities. A consensus is that both sexes are equally gifted in all academic domains, but girls are under-represented in support programs aimed at mathematically gifted secondary school students (Benölken, 2015). Another study investigated gender differences in 181 gifted students regarding achievement, academic self-concept, interests, and motivation in mathematics. Although male students obtained significantly higher test scores, there was no gender difference in scores (Preckel et al., 2008).

Contrary to earlier studies, (Hargreaves & Homer, 2008) found no significant gender difference in math performance for students aged 9 or 15 years. However, differences in attitudes were found, including the stereotypical view of mathematics that seems to be commonly held as a boy's subject. The findings further reveal that where 'gifted' girls perform and 'gifted' boys, their confidence in mathematics is lower than their performance might indicate (Threlfall & Hargreaves, 2008). Based on previous studies, it is shown that there is no difference in math problem-solving ability by gender, something that is very likely to happen. This finding is also supported by (Rinn et al., 2008)who stated that there was no difference based on gender regarding math achievement scores and no difference related to math self-concept scores in gifted students. Moreover, in Indonesia, according to (ACDP, 2013), there have been many good practices and innovations in mainstreaming gender equality in education.

Some scholars have diverse views regarding the role of ethnicity or gender in their performance in mathematics, exceptionally gifted students. Researchers have devoted much attention to gender differences in mathematics perception and performance. Although the gap has closed on several levels, significant differences remain. However, when one incorporates ethnicity into the mix, the picture becomes more complicated (Walters & Brown, 2012). For example (Catsambis, 1994) revealed the results of his research in South America that there was a significant difference in mathematics achievement between white students and black African-American students due to limited opportunities. (Birenbaum & Nasser, 2005) demonstrated the result of his study in Israel and found differences in mathematics learning achievement of students of Arab and Jewish descent in the context of gender caused by cultural differences between the two tribes, especially regarding the expectations of parents for boys and girls. Both studies implicitly state that differences in student achievement based on ethnicity only occur under specific conditions such as learning opportunities and traditional values.

In the context of giftedness, some studies have explored the role of ethnicity, particularly concerning the participation of gifted students in special gifted programs. Through multiple regression analysis, there was no statistically significant difference in the likelihood that students of various races and ethnicities would be identified as gifted students (Wanne et al., 2013). Meanwhile, another study found that currently, the screening of gifted students to participate in gifted programs has emphasized achievement and achievement and ignores local values that tend to discriminate against ethnic minority groups (Oakland & Rossen, 2005). Therefore, the results of the analysis that show no difference in the mathematical problem-solving abilities of gifted students based on ethnicity is a likely results.

4. CONCLUSION

This study confirms that the diversity of ethnicity and gender in high school is not a differentiating factor in the mathematical problem-solving skills of mathematically gifted students. It shows that giftedness is the main factor that plays a role in determining student performance when solving math problems. Gender and ethnicity will only play a role when equality in gaining educational access is still a severe issue, and traditional values are still believed to hinder these opportunities.

RECOMMENDATIONS

Various limitations in this study impact the inability of this study to explain differences in mathematical problem-solving skills more specifically, such as at the Orientation, Organiza-tion, Execution, and Clarification stages. Further research could be carried out on instructional development to meet the particular needs of gifted students.

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AUTHOR’S CONTRIBUTIONS

The author discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the author.

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